Air sealing a home is generally considered the most cost-effective way to reduce heating and cooling energy use. It also improves comfort and indoor air quality. Achieving a high level of air tightness requires more than just filling visible holes. High-performance homes have a continuous air barrier. The key word here is *continuous*. The secret to continuity is to identify large sheets of material that already exist and bridge the gaps – or joints – between them in order to completely seal the structural sheathing. Several good methods exist to install a continuous air barrier. Some are “homegrown” solutions based on skilled use of materials in the field, such as air-tight drywall (ADA) and adhesive attachment (gluing) of the sheathing. Others, like Siga membranes and ZIP System, are proprietary and therefore slightly more expensive. We’ll discuss these and other approaches in more detail.

Air Changes Per Hour (ACH)

Based on energy modeling, set a goal for air changes per hour under 50 Pascals of pressure (ACH50) using a blower door test. Fifty Pascals of air pressure is the common standard used on blower door tests. A typical airtightness goal for a cost-effective zero energy home would be from 0.6 to 2 ACH50.

Sealing the Outer Wall in Double Wall Construction

Conveniently, the outside surface of most modern homes is covered with large sheets of structural sheathing (plywood or OSB). Exterior sheathing can become a continuous air barrier by laying a solid bead of construction adhesive around the perimeter of each sheet. Another bead should be placed below bottom plates before walls are tipped up.These measures lock the sheathing to the outer face of the wall framing members and to the bottom plates, sealing an otherwise major air leak pathway. Framers already have tubes of construction adhesive on hand, although they will need more than they usually use.

To maintain continuity, the air barrier must be carried from the exterior sheathing to the ceiling drywall. The wall’s top-plate serves as the bridge. A gasket or Ecoseal on the inside face of the top plate will connect the ceiling drywall to the air barrier system.

Sealing the exterior has a major advantage. It covers most of the building including many of the framing connections inside the house. Even so, pay special attention to the continuity of the air barrier around windows, doors, sill seams, band joists, penetrations and the joints between roofs, walls and floors. Special care should be taken where multiple framing members occur together, such as built-up posts and rough openings. Air leaks where framing members meet can be significant and worsen as the framing dries and shrinks. Make sure all exterior sheathing is securely nailed. Repair any holes or breaks. High quality tape, such as 3M Flashing Tape, is very flexible and adheres well to wood, which makes it great for covering joints and gaps.

To conduct blower door directed air sealing, the ceiling drywall will need to be installed ahead of the normal construction sequence. This is necessary in order to depressurize the building for the test. Use smoke sticks to detect and seal the more difficult to see air leaks. Involve your subcontractors and crew. Be fanatical, systematic and persistent in finding and sealing every leak, checking your progress with the blower door as you go. To learn more about exterior air sealing, see Airtight Wall and Roof Sheathing: Arguments in Favor of Exterior Air Sealing.

Sealing Materials

In the process of air sealing a building, you’ll encounter all manner of leakage paths, including deep holes, cracks, joints between sheets, flat joints and 90-degree joints. The type of sealant you use depends on the type of leak.

Solid blocking and backing: Although it may seem counterintuitive, solid materials are important elements of a continuous air barrier. Most framing configurations include spots where the air barrier must cover a large gap across a cavity. In many cases, fire blocking is required in these locations, and adding a bit of caulk or foam will complete the seal. Rigid sheets are required to cover certain areas that are often overlooked, for example, the area behind showers and tubs. The walls behind fireplaces need to be covered and the fireplace cavity capped when these areas are in contact with exterior walls or ceilings. Generally you can use wood scraps for most of this work, keeping cost down.

Glue: Construction adhesive can be an effective sealant for specific applications, such as fixing wall framing to sheathing and under bottom plates. Because glue is rigid, there is some concern that it may crack as the building shifts over time. However, two advantages of adhesive are its low-cost and ready availability on most job sites. Just be sure to order extra for the air sealing function.

Caulk: Most caulk is designed to fill a joint that is no more than ½-inch deep and ½-inch wide, although products called elastomeric caulks can fill larger gaps. Joints that are the correct width, but too deep, such as the gap between a window frame and the rough opening, can be packed with backer rod first and the remaining space filled with caulk.

Foam: For larger gaps, expanding foam is an effective sealant. Dispensed from canisters through a gun, foam will fill gaps up to a couple of inches wide. However, such large gaps may need to be covered with a scrap of solid wood or OSB first and then foam filled in the remaining gaps. A good example of this is the large hole around a tub drain trap. Take care to fill gaps entirely. Openings around pipes can be difficult to see and suffer from an incomplete seal. One thing to note is that foam becomes brittle over time and may break if building elements, especially plumbing drains and vents, move over time.

Tape: In recent years, construction tape has become an important material for air sealing flat joints. It is often necessary to seal the joint where two framing members or sheets of wall sheathing touch each other. There is little if any gap to fill with caulk or foam. Tape easily spans the gap. Be sure to use construction tape that is very flexible and designed to adhere to wood, such as 3M Flashing Tape #8067.
Ecoseal: Intended for flat joints where framing members and sheet goods meet, this is a low-VOC sealant. This proprietary system is applied by trained applicators just before insulation. Ecoseal is elastomeric and so it will stretch, rather than crack, when the house settles. Despite its flexibility, it is not capable of filling gaps more than ¼-inch wide.

Duct mastic: This paste-like substance is intended for ducts, but solves the dilemma of getting a good seal on electrical boxes. A thick layer of mastic on the back of each box will seal wire penetrations and unused knockouts.

Sealing the Inner Wall

Install drywall on the walls in an airtight manner and finish it with a continuous coat of plaster or properly tape it to create an additional air barrier inside. One key location to air seal is the gap where drywall touches the top plate of the wall framing. If possible, seal the gap between ceiling drywall and top plates from above after the ceiling drywall is in place. Some builders staple a gasket to the face of the top plate before drywall to fill this gap. Others use either drywall adhesive or Ecoseal. While drywall adhesive costs less than Ecoseal, adhesive must be installed during the process of hanging the drywall and it is difficult to confirm that it’s done correctly. Ecoseal has the advantage of being a separate process that can be monitored. Because Ecoseal stays soft, it will adhere to drywall even after several days.

After the drywall has been installed and the inner envelope has been sealed, run the blower door again to identify and seal all remaining leaks.

Reduced Penetrations

Penetrations through the air barrier complicate air sealing, so minimizing penetrations can reduce time and money spent on air sealing. Here are some things that can be done to reduce penetrations:

1. Avoid recessed lighting. Use track lighting, pendants, or recessed cans placed in soffits that are within the conditioned space to keep the air barrier intact.
2. Eliminate bathroom exhaust fans by utilizing the ERV/HRV ventilation system provided they are sized properly and meet local code.
3. Choose a ductless heat pump (mini-split system) since refrigerant lines are much easier to seal than ducts.
4. Avoid plumbing on outside walls wherever possible. Only hose bibs should be installed on the outside walls.
5. Place all wires and plumbing in exterior double-stud walls in the interior set of studs.
6. Kitchen range hoods can be eliminated by using an ERV or HRV vent in the kitchen, provided it is permitted by code. It is important to locate the ventilation exhaust point at least six feet from the range to reduce the accumulation of grease in the ducts. The ERV/HRV exhaust in the kitchen should be sized properly to meet the airflow required by code.
7. All HVAC equipment and ducts should be inside the conditioned space. Ducts can be built into chases or soffits so that they are inside the thermal barrier.

Sealing Electric Boxes

After all electric boxes and wiring have been installed, seal the electrical boxes with spray foam, duct mastic, or a combination of the two. Be sure to cover all wire penetrations and unused knockouts. Once electricians have installed plugs and switches, the boxes should be sealed to the drywall with caulk.

Airtight Electrical Boxes

Airfoil airtight electrical boxes and Lessco airtight electrical boxes – although considerably more expensive than conventional single boxes – are preferred in many applications. They are important to use in vaulted ceilings and other vulnerable locations that cannot be sealed easily. Boxes in flat ceilings often can be sealed from the attic space. But if access is not available, airtight boxes would be appropriate in flat ceilings, too. Airtight boxes in exterior walls may be useful if the air leakage target is below 1.0 ACH50. They are not necessary on interior walls.

Sealing Windows and Doors

Window and door frames should be sealed to the wall frames with caulk or foam depending on the size of the gap. Casement windows are preferable to use because they close most effectively and form the best air seal. Compression gaskets and weather stripping give the best air seal. An airtight gasket should also be installed on the crawl space door.

Attic and Crawl Space Access

When possible place attic hatches and crawl space access doors in places where they will not penetrate the air barrier. For example, the attic hatch can often be located in a garage or gable end wall. Crawl space access can be place in an outside wall below the level of the insulated floor.

Double Entry Doors

If entry doors are exposed to cold winds, two doors can be installed to form an air lock. These double entry doors reduce drafts and increase comfort, often leading to lower thermostat settings. Double entry doors may not be cost-effective in all homes, but if the home is well designed, double entry doors can create a useful space, such as an entryway with a coat closet, or a mudroom.

Three-Point Latching Mechanisms

While, three-point latching mechanisms for doors are considerably more expensive than ordinary latches, they hold the door tightly against its weatherstripping and resist warping. They are especially important where double entry doors are not feasible, and where the doorway is exposed to cold prevailing winds or intense sun.

Air-Tight Vent Covers

Where external vents are used – such as for a clothes dryer – select vent covers that are as airtight as possible. An added advantage of using an air-tight vent cover is that it will help keep rodents and other critters out of the home.

Blower Door Directed Air Sealing

In order to reach an extremely low air-leakage target, it is important to conduct two or three functional blower door tests. For the first blower door test, the ceiling drywall needs to be installed and sealed ahead of the normal construction sequence, and exterior sheathing needs to be sealed as much as possible, but the drywall should not yet be installed on the walls. This creates a pressure boundary for testing while the outer wall can still be fully accessed for locating and sealing any leaks. Once the obvious gaps have been identified and sealed, the blower door should be run almost continuously to discover additional leaks using a smoke stick or your hands. All detected leaks should be sealed and rechecked while the blower door is running.

The house should be tested again after the plumbing and electric work have been completed to find and seal any further leaks. And a final blower door test should be conducted after all finishes and trim have been installed. This last check for leaks gives the final ACH value of the home.

Air Sealing Checklist

Using a simple checklist is helpful for systematically documenting every possible air leak during blower door tests. All potential air leakage sites identified on the checklist and in the design should be added to the scope of work of the appropriate subcontractors to be sure a thorough job is done. Use a Thermal By-Pass Checklist to identify areas that need sealing and use the excellent air sealing diagrams from Green Building Advisor.

Blower Door Test Challenges

Like most instruments, blower doors have a margin of error. Several factors can affect the test results, including wind, barometric pressure, and differences in operating procedures. At the level of air tightness needed for a zero energy home, these variations can be significant. In an attempt to better standardize the test, the same door should be used each time. Avoid testing on days when wind speeds exceed 15-20 mph. Extreme weather conditions and large shifts in barometric pressure should also be avoided. A door to the garage may have less exposure to wind. A multipoint test at various test pressures can be conducted and the curve can be calculated, which will give a more accurate reading. The Minneapolis Blower Door Tectite software is a helpful tool for multipoint testing.

Attention to Detail

Whatever the materials and techniques used for air sealing, the most crucial technique is to take your time, pay close attention to detail, and double check everything. With care, practice and experience, high levels of air tightness can be achieved at minimal cost.

For more on best practices for sealing air leaks see Tape It? Seal It? Glue It? Sealing Weather Barrier Seams. Detailed illustrations of air sealing procedures and problem areas can be found in the ENERGY STAR Thermal Enclosure System Rater Checklist.

Energy.gov and Joe Lstiburek, PhD, P.E., of Building Science Corporation, have teamed up to publish a helpful webinar focused on helping builders learn even more about best practices for building zero net energy homes.